NASA TECHNICAL TRANSLATION NASA TT F-11,570

NASA TT F-11,570

NOTES ON THE PROBLEM OF CONTROLLING MANNED SPACECRAFT

N. N. Moiseyev

Translation of "Zamechaniya o Probleme Upravleniya Pilotiruyemogo Kosmicheskogo Apparata"
Paper presented at the Eighteenth Congress of the International Astronautical Federation, Belgrade, 25-30 September, 1967, 3 p.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 FEBRUARY 1968

NOTES ON THE PROBLEM OF CONTROLLING MANNED SPACECRAFT

N. N. Moiseyev

ABSTRACT. One of the most important problems concerning manned spacecraft development is that of the synthesis of a control system. Obviously, any spacecraft must contain a computer; this computer will generally be a specialized, rather than universal, computer, required to solve only a certain definite range of preprogrammed problems. The presence of the on-board computer requires that the problem of synthesis be stated anew. This is explained using the example of orbital adjustments.

The problem of manned spacecraft is doubtless among the most important problems of contemporary astronautics. /1[1]

This problem has many aspects. One of the most important problems involved in its solution is the problem of the synthesis of a control system.

Apparently it must be considered a postulate that the spacecraft will contain a computer. The range of problems to be solved on board the spacecraft is so broad, and these problems are so complex, that it would hardly be possible to attempt their solution without using an electronic computer. Also, certain technical prerequisites must be met. Actually, it is possible at the present time to produce small computers. These computers may also be specialized, rather than universal computers, since they must solve only a certain definite range of preprogrammed problems.

The presence of the on-board computer forces us to state the problem of synthesis anew. Let us explain this using the example of orbital adjustments.

Suppose at a given moment we have detected a deviation in the position of the spacecraft from the planned position. Let us represent this deviation by x_0. Then, we can require that this deviation be eliminated in time T with the minimum expenditure of energy I(u). From this condition, we determine the optimal control $U_1(t,x_0)$. However, at moment T, due to random perturbations, once more the spacecraft is found to be in a condition other than the calculated condition. Repeating our discussions above, we once more /2

[1] Numbers in the margin indicate pagination in the foreign text.

produce a control $U_2(t,x_1)$, which would return the spacecraft to the required trajectory by moment $t = 2T$ if there were no perturbation, etc.

With this statement of the problem, the selection of time T remains indefinite. It must be selected from the condition of the minimum mean value of $(1/T)I(u)$, under the condition that dispersion $\overline{x^2}$ will not exceed its permissible value.

Time T should be expended in the calculation of the position and the prediction of the random process of perturbations. The quality of the prediction in turn will influence the dispersion.

We note that this control system requires a system with feedback. The realization of such a system requires economical algorithms for the solution of the variation problems involved. Such algorithms already exist and, consequently, the realization of such a system is a completely practical matter.

This type of system can be considerably more economical in the sense of energy expenditure for control than the standard organization of feedback. /3

I have just presented an example showing that a completely new set of problems of synthesis of control systems with feedback may arise in the problem of controlling a manned satellite.

A number of other variants of similar control systems may be suggested. Of course, it is impossible to describe them in a brief presentation.

Translated for the National Aeronautics and Space Administration under contract No. NASw-1695 by Techtran Corporation, P.O. Box 729, Glen Burnie, Maryland 21061